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(71) Applicant *(for all designated States except US)*: **OBDUCAT AB** [SE/SE]; Box 580, S-201 25 Malmö (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MONTELIUS, Lars** [SE/SE]; Montelinvägen 16, S-237 35 Bjärred (SE). **HEIDARI, Babak** [SE/SE]; Södra Ljungvägen 10, S-244 65 Furulund (SE). **STJERNHOLM, Thord** [SE/SE]; Stenskogsvägen 24, S-243 31 Höör (SE).

(74) Agent: **AWAPATENT AB**; Box 5117, S-200 71 Malmö (SE).

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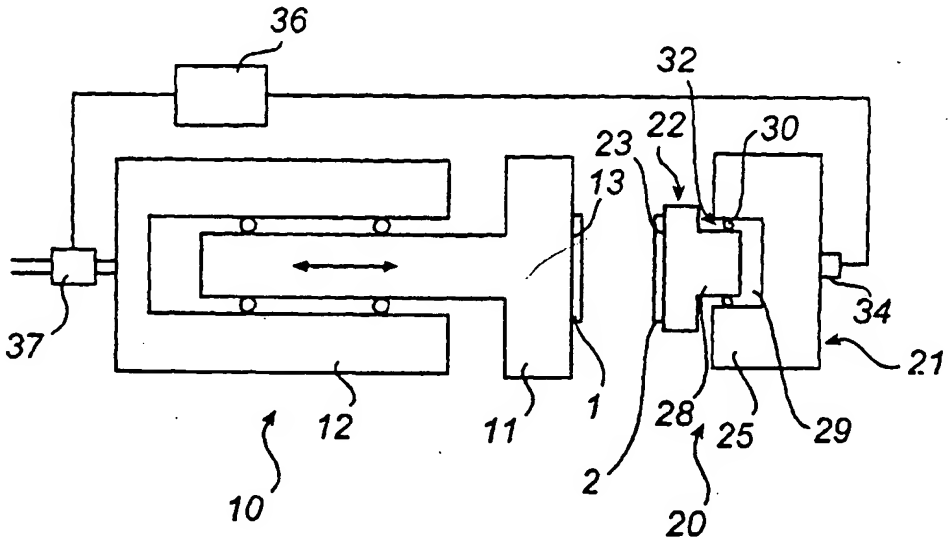
(54) Title: DEVICE FOR TRANSFERRING A PATTERN TO AN OBJECT



(57) Abstract: A device for transferring a pattern, especially micro- or nanostructures, from a stamp (1) to an object (2) comprises a first contacting means (11) with a receiving surface (13) for the stamp (1) and a second contacting means (20) with a receiving surface (23) for the object (2). A pressing means (10) is adapted to operate at least one of the contacting means (11, 20) for contacting the stamp (1) with the object (2). One contacting means (11, 20) comprises a base (21) and a holder (22). The holder (22) has a first end which defines one of the receiving surfaces (23) and a second opposite end which is pivotally connected to the base (21) in such a manner that the stamp (1) and the object (2) are automatically placed in a mutually parallel position when contacting each other.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DEVICE FOR TRANSFERRING A PATTERN TO AN OBJECT

Field of the Invention

The present invention relates generally to transferring a pattern from a stamp to an object. The invention relates especially to production of micro- and nanostructures.

Background Art

A promising technique of producing nanostructures, i.e. structures in the order of 100 nm and smaller, is so-called nanoimprint lithography. This technique is described in the document US-A-5,772,905, which is incorporated herewith by reference. In such lithography, the main steps of which are schematically shown in Figs 1a-d, a pattern of nanostructures is transferred from a stamp 1 to an object 2. The object 2 consists of a substrate 2a and, applied thereto, a film 2b of a polymer material (resist). After heating of the film 2b to a suitable temperature, the stamp 1 is pressed into the same (Fig. 1b). The stamp 1 is then released from the object 2 when recesses 3 of a desired depth have been formed in the layer 2b (Fig. 1c). Subsequently any remaining film in the recesses 3 is removed, for instance by etching, thereby exposing the substrate 2a. In subsequent process steps (not shown), the pattern in the film is reproduced in the substrate or in some other material which is applied to the substrate.

A device according to the above-mentioned US patent for carrying out the above lithographic process comprises a first contacting means with a receiving surface for the stamp, a second contacting means with a receiving surface for the object, and a pressing means for contacting or joining the first and second receiving surfaces with each other.

The film applied to the substrate is very thin, typically 50-200 nm. For even structuring of the object,

the stamp and the object must thus be mutually parallel with an accuracy of a few nanometres. In industrial applications, the object can have a diameter of about 15-30 cm, which means that the surfaces contacting each other can have a maximum angle of inclination of about 10^{-7} rad. A greater inclination between the stamp and the object can, in addition to uneven structuring of the object, also result in the latter being smashed. In fact the substrate is usually made of a brittle material, e.g. Si/SiO_2, GaAs or InP, and the pressure exerted upon the substrate during contacting is high, typically 4-10 MPa.

A conceivable solution to the above problems would be to fix the receiving surfaces of the device in a mutually fully parallel relationship once and for all. This requires, however, that all objects have perfect plane-parallel flat sides. For reasons of manufacture, this is not possible, and therefore the device must be adjusted for each individual object.

According to a previously suggested solution to this problem a plurality of power or pressure sensors are mounted in the receiving surface of the stamp or the object. A control unit is adapted to actively control the mutual angular position of the contacting means based on the thus measured pressure distribution. However, this is an expensive and complicated solution, which is also difficult to scale up for structuring of large objects.

Summary of the Invention

An object of the invention is to wholly or partly overcome the above problems of prior art. More specifically, it is an object to provide a simple device for transferring a pattern from a stamp to an object with a high degree of mutual parallelism between the stamp and the object.

It is also an object of the invention to provide such a device that allows contacting of the stamp with the object under high pressure.

It is a specific object of the invention to provide a device which is suited for transferring micro- or nano-structures to the object.

These and other objects that will appear from the following description are now achieved by means of a device according to claim 1. Preferred embodiments are defined in the subclaims.

In the inventive device, the receiving surfaces, and the stamp and the object which are received thereon, can be put together in a non-parallel position. When the stamp is contacted with the object, they will automatically be brought into a mutually parallel position by the force acting between them pivoting one receiving surface relative to the other receiving surface. The device is of a simple design and can be formed to allow contacting of the stamp with the object under high pressure. The device can also easily be scaled up for structuring of objects having a greater diameter or thickness.

According to a preferred embodiment, the holder is pivotally connected to the body via coacting male and female portions, which between them define a compartment for receiving a fluid, preferably a hydraulic fluid. Such a device allows soft and gradual contacting of the stamp with the object owing to the fact that the fluid is able to impart a certain amount of inertia to the pivoting motion of the holder. The fluid in the compartment between the male portion and the female portion can also absorb sudden changes in pressure that may arise during contacting, which also promotes soft and gradual contacting. A further advantage of this embodiment resides in the possibility of detecting via a pressure sensor the pressure established in the chamber, which can be converted into an almost exact value of the actual contact pressure between the stamp and the object. Based on the pressure detected by the pressure sensor, the pressing means can thus be caused to produce a well-defined pressure between the stamp and the object.

According to a further preferred embodiment, the male portion is inserted into the female portion in such manner that the compartment encompasses the male portion arranged in the female portion. As a result, the mechanical contact between the male and female portions is minimised.

When the stamp and the object, during contacting, are pivoted to a mutually parallel position, the largest amount of forces is exerted upon the peripheral edges of the object. These forces are minimised in a preferred embodiment by the female portion defining a mouth portion, which is in sealing contact with a circumferential portion of the male portion, and by the circumferential portion having a diameter which is equal to or smaller than the diameter of the receiving surface of the holder.

To achieve an optimally even contacting of the stamp with the object, it is preferable for the female or male portion arranged on the holder to be coaxial with the receiving surface of the holder.

Brief Description of the Drawings

The invention and its advantages will be described in more detail below with reference to the accompanying schematic drawings which by way of example illustrate currently preferred embodiments of the invention.

Figs 1a-1d illustrate transfer of a pattern from a stamp to a substrate by nanoimprint lithography according to a known process.

Fig. 2 is a basic sketch of a device according to the first embodiment of the invention.

Fig. 3a is a side view on a larger scale of the abutment illustrated in Fig. 2, some inner parts being indicated by dashed lines, and Fig. 3b is a sectional view taken in the centre plane of the abutment in Fig. 3a.

Figs 4-7 are sectional views taken in the centre plane of abutments according to alternative embodiments of the invention.

Description of Preferred Embodiments

Fig. 2 is a schematic view of a device according to a first embodiment of the invention. The device, which is intended to transfer a pattern from a stamp 1 to an object 2, comprises a press 10 and an abutment 20 coacting with the press. The press 10, which can be of a prior-art type, such as a hydraulically operated press, has a piston element 11 which is movable back and forth in a well-defined direction relative to a fixedly arranged body 12 of the press 10. The piston element 11 has on its side facing away from the body 12 a surface 13 for receiving the stamp 1.

The device further comprises an abutment 20 which comprises a fixedly arranged base 21 and a holder 22, which on its side facing away from the base 21 has a surface 23 for receiving the object 2. The surface 23 is of essentially the same extent as the object 2 to be received thereon. A locking means (not shown) for securing the object 2 is arranged at the surface 23. This locking means can of an arbitrary kind, but for automatic production it is preferable to use sub-atmospheric pressure in this securing of the object. The holder 22 is pivotable relative to the base 21, as will be described in more detail with reference to Figs 3a-3b.

In the embodiment according to Figs 3a-3b, the base 21 comprises a vertical supporting plate 24 and a female portion in the form of a projection 25, which is sleeve-shaped and, thus, defines a cavity 26. The holder 22 comprises a base plate 27, which on one side defines the surface 23 and on its other side has a male portion in the form of a projecting shaft 28 which is arranged coaxially with the receiving surface 23. The distal end of the shaft 28 is inserted into the cavity 26 and forms together therewith a closed compartment 29. Both the

shaft 28 and the cavity 26 are circular in cross-section. A seal in the form of an O ring 30 is arranged in a circumferential groove 31 at the mouth area 32 of the cavity 26. The O ring 30 rests against the circumferential surface of the shaft 28 to seal the compartment 29 against the ambient air. The compartment 29 is filled with a suitable hydraulic fluid of low compressibility, such as a brake fluid for vehicles.

When the stamp 1 is pressed against the object 2, an increased pressure is generated in the compartment 29 and strives to press the O ring 30 out of the groove 31. In order to counteract this, the mouth area 32 has a circumferential guide lug 33 connecting to the groove 31. In order to minimise fluid leakage from the compartment 29 via the O ring 30, a flexible cloth 38, for instance of rubber material, can according to an alternative embodiment as shown in Fig. 7 be sealingly fixed to the inner walls of the compartment, thereby forming a fluid-limiting membrane 38 in the compartment 29. The fluid is caught in the space between the membrane 38 and the inner walls of the compartment 29 and absorbs forces from the distal end of the shaft 28, which distal end abuts against the membrane when the stamp 1 is pressed against the object 2. If there is an O ring as shown in Figs 3a-b, this will affect the distal end of the shaft in case of great inclinations of the same. By not having an O ring in this alternative embodiment, the distribution of forces will be more uniform across the entire surface of the stamp while pressing against the object.

A pressure sensor 34 extends through a bore 35 in the supporting plate 24 into contact with the fluid in the compartment 29, either direct or via a partition (not shown). According to Fig. 1, the pressure sensor 34 is connected to a control unit 36, such as a computer. The control unit 36 is connected to the press 10 and controls its contacting of the stamp 1 with the object 2 via a pressure control means 37, e.g. a pump/valve which con-

trols a hydraulic pressure acting on the piston element 11.

In a preferred embodiment, the holder 22 comprises a heating means (not shown) for heating the object 2. Moreover the holder 22 suitably has a cooling means in the form of a cooling loop K which is passed by a cooling medium (Fig. 3a). This allows, in addition to cooling of the object 2, a temperature stabilisation of the shaft 28 to prevent changes in the shape thereof.

The operating mode of the device will be briefly described below with reference to Fig. 1. The control unit 36 actuates the pressure control means 37 to move the piston element 11 towards the immovable abutment 20 for contacting with the same. Normally, the stamp 1 mounted on the piston element 11 is not quite parallel with the object 2 mounted on the abutment 20. In the contacting with the object 2, any inclination between the stamp 1 and the object 2 will be automatically eliminated by the action of forces between them causing the holder 22 to pivot relative to the base 21 about a pivot point located in the centre of the mouth area 32. The fluid in the compartment 29 damps the motion of the holder 22 during the paralleling, thereby allowing the contacting to take place softly. Subsequently the parallel receiving surfaces 13, 23 are pressed against each other until the pressure sensor 34 registers a desired contact pressure, after which the control unit 36 causes the press 10 to lock the piston element 11 for a given period of time. After that the control unit 36 actuates the pressure control means 37 to move the piston element 11 away from the abutment 20, so that the structured object 2 can be removed from the receiving surface 23.

Most satisfactory results have been achieved with the device illustrated in Figs 2-3 in the manufacture of micro- and nanostructures. A substrate of Si/SiO_2 was provided with a 300 nm thick layer of 950K PMMA. This object was baked at 180°C for 24 h. Then the object was

mounted in the device, after which the PMMA layer was heated to about 170°C. At this temperature, the heating was terminated, and a stamp with a pattern of 300 nm deep structures was pressed against the object at a pressure of about 60 bar for about 1 min. At the same time the object was cooled to about 80°C. The thus structured object had a depth of pattern of about 200 nm with good evenness across the entire substrate, whose diameter in this case was about 5 cm.

Fig. 4-6 are schematic views of different alternative embodiments of the abutment 20, parts equivalent to those in Figs 2-3 having the same reference numerals.

In Fig. 4, the coacting female and male portions 25, 28 of the base 21 and the holder 22 are of a complementary shape, more specifically a part-spherical shape. This embodiment will probably result in a somewhat more flexible contacting of the stamp 1 with the object 2.

In Fig. 5, the receiving surface 23 of the holder 22 is of essentially the same diameter as the circumferential surface of the male portion 28 in the mouth area.

In Fig. 6, the base 21 is provided with a projecting male portion 28' which coacts with a female portion 25' formed in the holder 22.

However, it should be emphasised that the invention is not restricted to the above embodiments and that several modifications are feasible within the scope of the appended claims. For instance, the stamp 1 and the object 2 can change places in the accompanying drawings. In another alternative, the holder 22 is pivotally arranged on the piston element 11 instead of on the base 21 of the abutment 20. According to one more alternative, the abutment 20 is arranged to move towards the piston element 11. It should also be appreciated that the holder 22 in a conceivable embodiment is pivotally connected to the base 21 via a mechanical coupling, instead of the hydromechanical coupling described above.

CLAIMS

1. A device for transferring a pattern from a stamp (1) to an object (2), comprising a first contacting means (11) with a receiving surface (13) for the stamp (1), a second contacting means (20) with a receiving surface (23) for the object (2), and a pressing means (10) which is designed to operate at least one of the contacting means (11, 20) for contacting the stamp (1) with the object (2), c h a r a c t e r i s e d in that one of the first and the second contacting means (11, 20) comprises a base (21) and a holder (22), the holder (22) having a first end which defines one of said contacting surfaces (23) and a second opposite end which is pivotally connected to the base (21) in such manner that the stamp (1) and the object (2) are automatically placed in a mutually parallel position when contacting each other.

2. A device as claimed in claim 1, wherein the holder (22) is pivotally connected to the base (21) via coacting male and female portions (28, 25; 28', 25'), which between them define a compartment (29) for accommodating a fluid, preferably a hydraulic fluid.

3. A device as claimed in claim 2, wherein the male portion (28; 28') is inserted into the female portion (25; 25') in such manner that the compartment (29) encompasses the male portion (28; 28') arranged in the female portion (25; 25').

4. A device as claimed in claim 2, wherein the compartment (29) is formed at said opposite end of the holder (22).

5. A device as claimed in any one of claims 2-4, wherein one of said male and female portions (28, 25; 28', 25') is arranged on the holder (22), preferably coaxially with the receiving surface (23) of the holder (22).

6. A device as claimed in any one of claims 2-5, wherein the female portion (25; 25') defines a mouth portion (32), which is in sealing contact with a circumferential portion of the male portion (28; 28').

7. A device as claimed in claim 6, wherein the mouth portion (32) comprises a sealing element (30) which is made of a flexible material and abuts against the circumferential portion of the male portion (28; 28').

8. A device as claimed in claim 6 or 7, wherein the circumferential portion is essentially circular.

9. A device as claimed in any one of claims 6-8, wherein the circumferential portion has a diameter which is equal to or smaller than the diameter of the receiving surface (23) of the holder (22).

10. A device as claimed in any one of claims 2-9, wherein the male portion (28) is formed at the opposite end of the holder (22), and wherein the female portion (25) is formed in the base (21).

11. A device as claimed in any one of claims 2-9, wherein the female portion (25') is formed at the opposite end of the holder (22), and wherein the male portion (28') is formed in the base (21).

12. A device as claimed in any one of claims 2-11, wherein a pressure sensor (34) is adapted to detect the pressure of the fluid accommodated in the compartment (29).

13. A device as claimed in claim 12, wherein the pressure sensor (34) is arranged in the base (21).

14. A device as claimed in claim 12 or 13, wherein a control unit (36) is adapted, based on the pressure detected by the pressure sensor (34), to cause the pressing means (10) to establish a given pressure between the stamp (1) and the object (2).

15. A device as claimed in any one of the preceding claims, wherein the holder (22) contains a cooling loop (K) to be passed by a cooling medium.

16. A device as claimed in any one of the preceding claims, wherein the stamp (1) has a pattern of micro- or nanostructures.

17. A device as claimed in any one of the preceding claims, wherein the object (2) comprises a substrate (2a) and a layer (2b) of a polymer material applied thereto.

18. A device for transferring a pattern from a stamp (1) to an object (2), comprising a first contacting means (11) with a receiving surface (13) for the stamp (1), a second contacting means (20) with a receiving surface (23) for the object (2), and a pressing means (10) which is designed to operate at least one of the contacting means (11, 20) for contacting the stamp (1) with the object (2), c h a r a c t e r i s e d in that one of the first and the second contacting means (11, 20) comprises a base (21) and a holder (22), the holder (22) having a first end which defines one of said receiving surfaces (23) and a second opposite end which is pivotally connected to the base (21) via coacting male and female portions (28, 25; 28', 25') which between them define a compartment (29) for accommodating a fluid, preferably a hydraulic fluid, in such manner that the stamp (1) and the object (2) are automatically placed in a mutually parallel position when contacting each other.

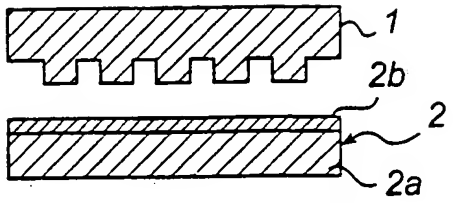

Fig. 1a

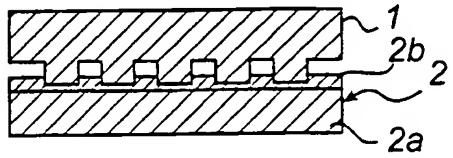

Fig. 1b

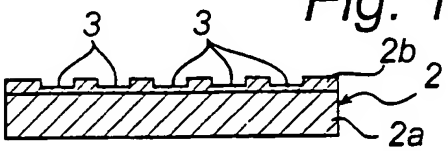

Fig. 1c

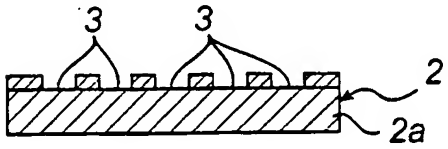

Fig. 1d

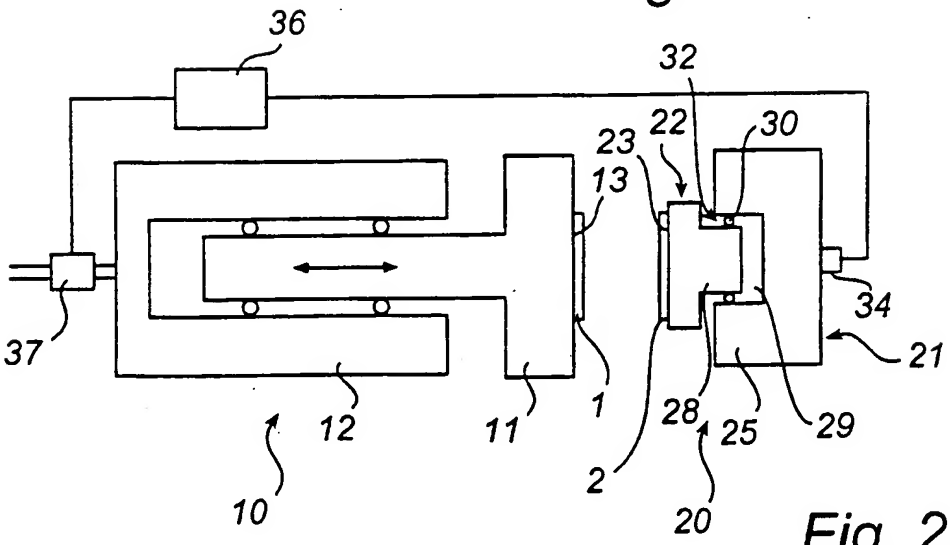

Fig. 2

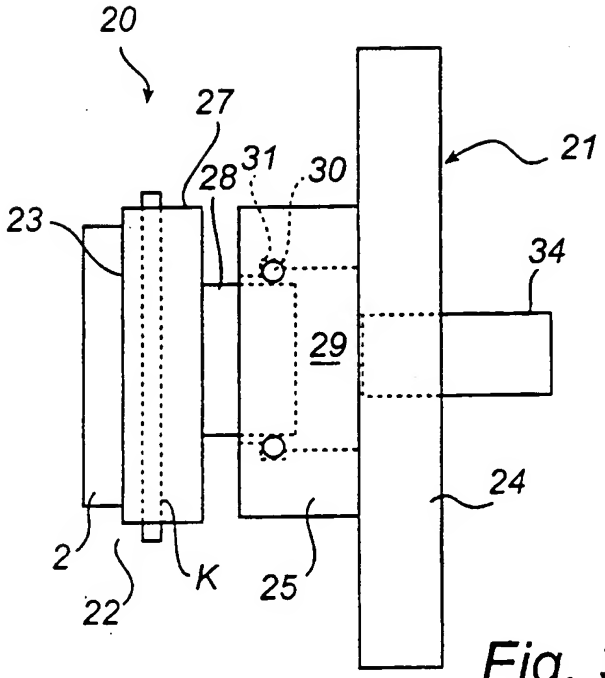
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Fig. 3a

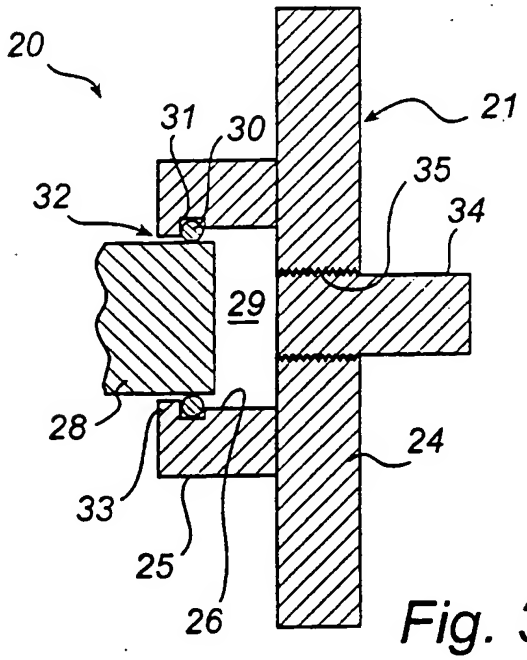
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Fig. 3b

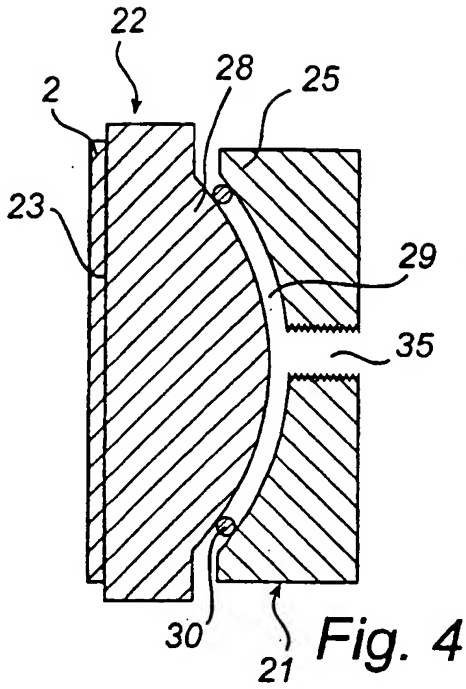

Fig. 4

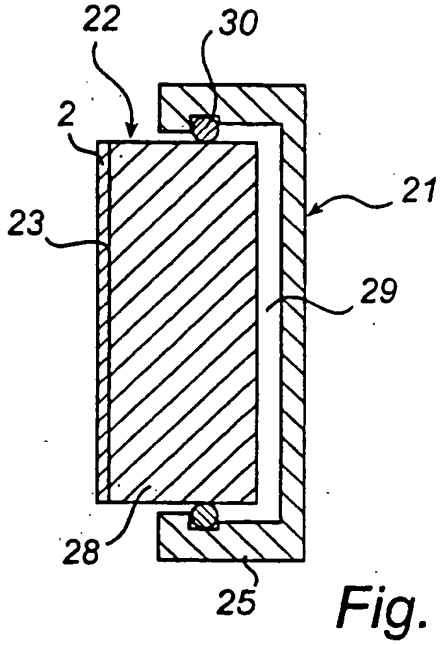

Fig. 5

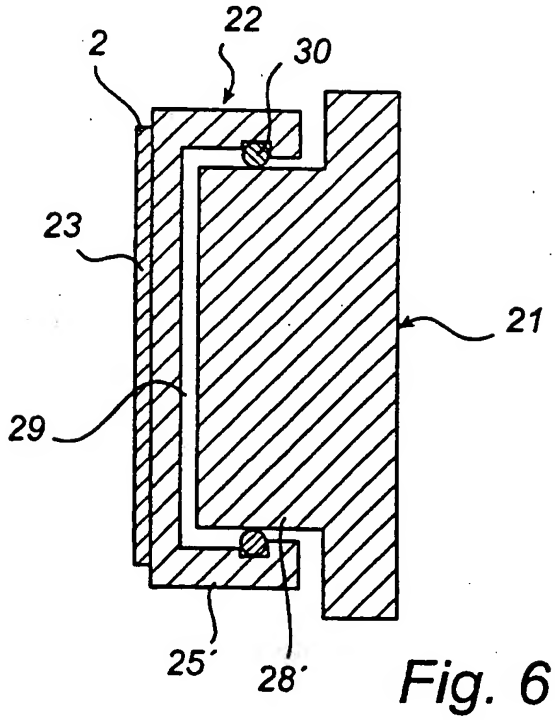

Fig. 6

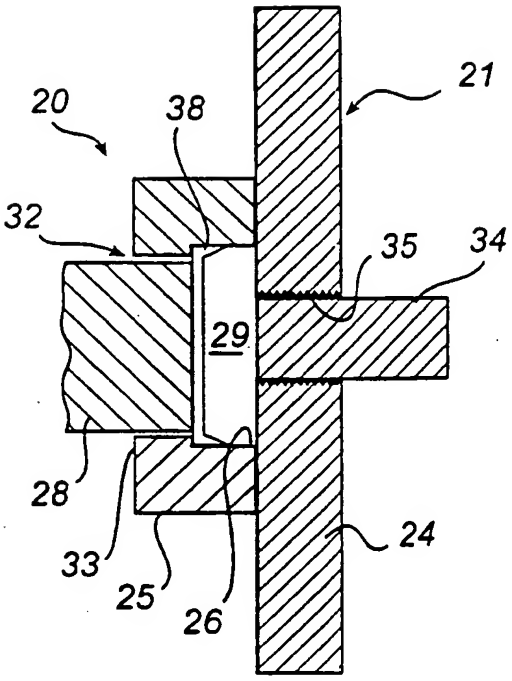

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/00527

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G03F 7/00, B41M 1/06, B81C 1/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B41M, B81C, G03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

QUESTEL: EDOC, WPIL, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6027595 A (THOMAS J. SULESKI), 22 February 2000 (22.02.00), column 1, line 15 - line 19; column 4, line 7 - line 11; column 7, line 29 - line 49, figures 3a-3c --	1-18
A	US 5947027 A (TIMOTHY P. BURGIN ET AL), 7 Sept 1999 (07.09.99), column 4, line 39 - column 8, line 10, figure 3 --	1-18
A	US 5576147 A (HENRY GUCKEL ET AL), 19 November 1996 (19.11.96), column 17, line 12 - line 62, figures 34-39 -- --------	1-18

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 May 2001	19 -06- 2001
Name and mailing address of the ISA Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bengt Christensson/MP Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/04/01

International application No.
PCT/SE 01/00527

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6027595 A	22/02/00	AU 4963799 A	24/01/00
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